Basic Plastic Surgery for Orthopedic Surgeons

14

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Wounds

Wounds are a common problem throughout the developing world and closure options are often a source of confusion. The history for a wound should include the following: causative event, chronicity of the wound, clinical course, and current treatment as well as a history of diabetes, tobacco use, malnutrition, HIV, and tetanus immunization. Examination of the wound will determine if it is clean, healthy, infected, or necrotic. All infected and necrotic tissues need to be debrided and the infection under control before closure.

Primary Closure

Primary wound closure requires the fewest long-term resources and the shortest wound healing time and is usually appropriate for patients who present within 6–8 h after injury (up to 24 h for face and some scalp wounds). If the wound cannot be closed without tension, it is better to leave it open to heal by secondary intension, create a flap, or skin graft.

Delayed Primary Closure

Delayed primary closure is appropriate for wounds that are best treated by primary closure, but are over 6 h old, have questionably viable tissue at their base, or would have a very tight skin closure if closed primarily.

The wound is cleaned, packed open, and in 48–72 h reevaluated to be closed or re-debrided. It is useful to pre-place the skin sutures at the time of the first procedure. If closure is possible at the dressing change, the pre-placed sutures obviate the need for a second anesthetic. In austere environments, late presentation of wounds is common, making delayed primary closure a useful tool.

Secondary Closure

If the patient shows up many hours after injury or there is evidence of significant wound contamination, ongoing infection, or tissue necrosis such that primary closure is not possible or would be done under tension, it is best to clean the wound, debride the nonviable tissues, and leave it open to heal secondarily with regular dressing changes.

Local Care and Dressings

Studies show that wounds heal best in a moist environment [1] and there are many synthetic dressings and gels for wound care, these are

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expensive and unlikely to be available. Wet to dry saline or dilute Dakin's solution dressings work well. Availability of gauze can also be a challenge. Dressings are best changed twice a day, though daily may be all that is possible (Boxes 14.1 and 14.2).

Box 14.1 Saline Solution

Boil a liter of water for 15 min in a covered pot. Add 1 tsp (5 ml) of table salt or cooking salt to this solution. Allow to cool, then store in a container with a tight lid. *NB*: this solution should not be used as an eyewash solution.

Dakin's Solution (*dilute sodium hypochlorite solution*)

For ¼ strength solution:

To a liter of NS, add 1.5 tsp of Clorox (sodium hypochlorite solution 5.25 % or plain household liquid bleach not concentrated). For ½ strength, double the Clorox. The container should be protected from light by wrapping it in aluminum foil and used within 3 days.

Box 14.2 Sugar Dressings

Sugar, as well as honey, has been used on open wounds including burns for centuries. It may work by decreasing wound pH, promoting epithelialization, or decreasing tissue edema through osmotic effects. In many areas it is cheap and readily available.

Place gauze moistened with betadine or saline onto wound. Coat this with sugar (~0.5–0.75 cm thickness). As the sugar draws moisture from the wound—an important component of the antibacterial properties of this dressing—the sugar will liquify. When this occurs, bacterial growth is promoted, so it is critical to change the dressing or add more sugar several times/day.

Vacuum-assisted closure (VAC) devices are frequently used in high-income countries to deal with problem wounds without resorting to flaps or grafts. Though presently expensive or nonexistent in low-income countries, the technology is changing such that they will become more readily available. Box 14.3 gives instructions for making a VAC from locally available materials.

Box 14.3 Do-It-Yourself Negative Pressure Wound Therapy

Supplies

Flexible tubing—similar to Jackson-Pratt drain tubing

Adhesive dressing such as Op-site or multiple layers of Saran wrap

Absorbent dressing material—gauze, foam prep sponges, OR towels, Kerlix, and kitchen sponges

Suction apparatus—requires access to wall suction or portable suction machine or a strong "hemovac-type" suction device.

Instructions

Place absorbent dressing material onto wound

- Place tubing within or on top of this material, not directly on the wound
- Cover with adhesive dressing or layers of Saran wrap
- Connect to suction (75–100 mmHg if you have a way to measure it, if not consider intermittent suction)
- Change every few days as needed [2, 3]

Skin Grafts

The following wounds will need a skin graft or flap because secondary closure will result in scar contracture that can severely limit function or cause significant disability:

- Wounds that will take more than several weeks to heal
- Wounds with exposed tendons, bone, and nerves

- Wounds in creases—antecubital fossa, dorsum of the ankle, back of the hand, and axilla

A split-thickness skin graft (STSG) is a partial thickness graft that preserves some of the dermis at the donor site, allowing it to heal on its own. A full-thickness skin graft (FTSG) takes the full thickness of the skin for the graft, requiring the donor site to be closed primarily.

Skin grafts receive their circulation from the recipient bed, making it critical that the wound is clean and the graft sutured in place. To prevent shear forces and promote vascular ingrowth at the graft-bed interface, the graft must be secured with a tie-over bolster, bulky dressing, or plaster splint and left undisturbed for 5–7 days. An STSG has a better chance for successful take on less than optimal surfaces than a thicker FTSG. An STSG can be used on wounds with exposed bone or tendons only if the thin, vascular overlying periosteum or peritenon is intact.

STSG

Most hospitals in austere settings have Humby or Watson knives to harvest an STSG (Fig. 14.1). The thickness setting should be 0.011–0.015 inch (0.25–0.4 mm); however, the dialed-in calibration on the knives is rarely reliable. To ensure proper graft thickness, adjust the opening of the blade so that the beveled edge of a #10 blade fits snuggly into the opening.

The most common donor site is the thigh. Wipe off any antibacterial solution that was used to prepare the site. Apply a sterile lubricant, such as mineral oil or vaseline from vaseline gauze to both the donor site and the instrument used to harvest the graft.

Technique

1. Have an assistant flatten the donor site, by placing tension on the skin with gauze or a wide flat object.
2. Hold the Watson or Humby knife with the sharp edge at a 45° angle to the skin.
3. With a back-and-forth motion, run the knife slowly over the tight skin.
4. As the graft skin is being taken, look at the wound. If fat is seen, the graft is too thick. If no pinpoint areas of bleeding are seen (paprika sign), it may be too thin (Fig. 14.2).
5. When enough graft has been harvested, cut the skin graft from the donor site with scissors.

Care of Donor Site

If local with epinephrine was not used at the start, apply a gauze wet with epinephrine solution (add 500 ml of saline to 1 ampule of 1:1,000 epi) to the donor site to control bleeding. Treat the donor site like a superficial burn, covering

Fig. 14.1 The operator is holding a Humby knife at a 45°-angle while taking the STSG. A broad sterile wooden board puts pressure on and flattens the skin ahead of the knife

Fig. 14.2 The Paprika sign of small punctate bleeding vessels on the surface of an STSG donor site

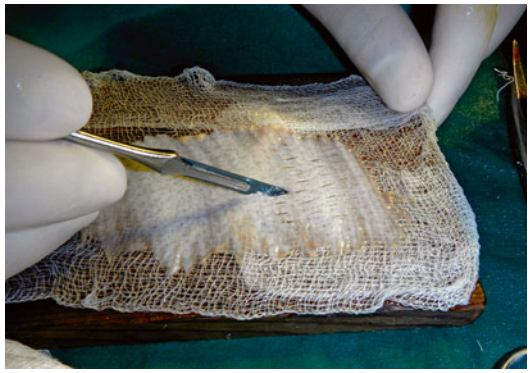

Fig. 14.3 Meshers are often unavailable. Many small cuts, made in a precise, concerted fashion will help expand the graft size. A wooden "cutting board" helps control the depth and size of the cuts

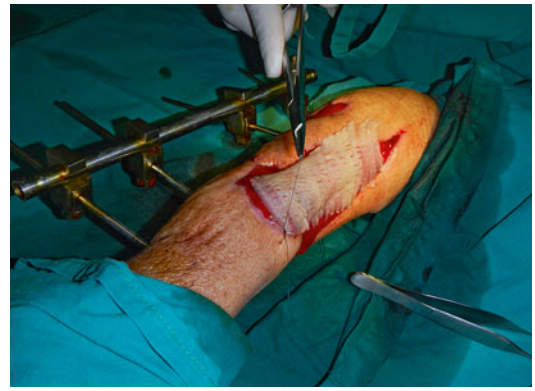

Fig. 14.4 STSG being sewn in place. Suturing from the graft to the wound edge stabilizes the graft and prevents it from displacement

it with an adherent plastic dressing or a single piece of xeroform gauze and cover with a dressing. Remove the dressing at 24 h, leaving the xeroform open to air. It will form an eschar that will separate over the next 2–3 weeks.

FTSG

Primary donor sites for FTSG are the mobile skin of the lower abdomen, inner upper arm, and the preauricular area where the donor site can be closed primarily. Cut through the full thickness of the skin, and when the graft is free, place the epidermis side down, draped over a gauze-covered finger, and using sharp, curved scissors remove the underlying fat. This is critical, as fat will impede vessel ingrowth and the graft will not take.

Preparation of the Skin Graft

Place the graft on the wound dermis side down. Cutting holes in the graft with an 11 blade or scissors, pie crusting, helps it to cover a larger area, but without a true mesher, one must place a lot of cuts in the graft for it to significantly expand in size (Fig. 14.3). Pie crusting allows egress of serum or blood that prevents the graft's take. Suture from the graft to the edge of the recipient wound edge to keep the graft from displacing (Fig. 14.4). The graft can be secured with a tie-over bolster by leaving 6–8 cm lengths of suture spaced radially around the graft. These are tied over a mounded dressing of xeroform, Vaseline, or damp gauze to stabilize the graft. Plaster splints are helpful for immobilization and elevation to decrease swelling and promote healing.

Flaps

Wounds that require flap coverage are usually those with exposed bone or tendon or are in an area where a skin graft is not sturdy enough for long-term coverage, such as a pressure sore. A flap is a vascularized tissue, usually skin, fascia, or muscle, or a combination. A local flap can be created if there is sufficient tissue around the wound that can be moved into the defect. When local tissue is not available, a distant flap must be created. Initially the circulation to the flap comes from the donor tissue with gradual ingrowth of vessels from the recipient wound bed. Use of distant flaps needs to take into consideration the position of the parts and comfort for the patient to prevent joint stiffness due to immobility.

General Principles

To optimize circulation and reliability of a skin flap, heed the 3:1 rule: the flap should not be longer than three times its width. Proximally based flaps are more reliable than those based on dis-

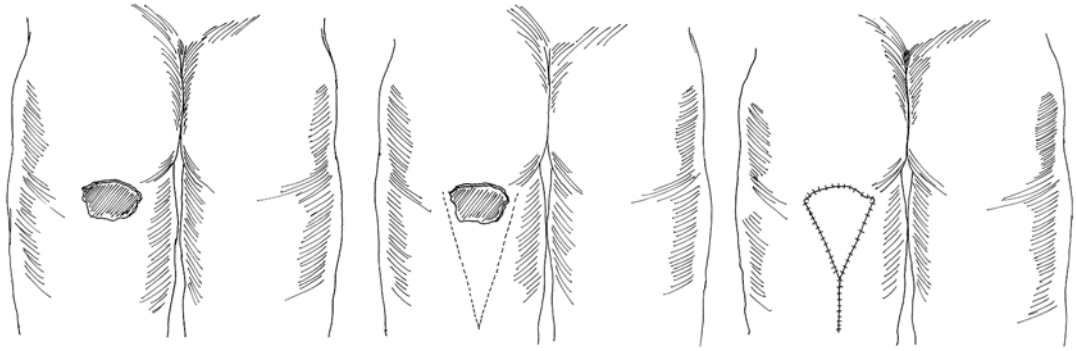

Fig. 14.5 Line drawing of V-Y plasty flap for covering an ischial pressure sore (Courtesy of Nadine Semer)

tal circulation. Delaying the flap—whereby the flap is incised and freed from all attachments except the pedicle and then loosely sutured back in place—will improve circulation by opening vessels within it. Wait 2–3 weeks to move the tissue into the defect. Close the flap defect with an STSG when a primary closure would result in undue tension.

Local Flaps

V-Y Advancement Skin Flap

A V-Y advancement skin flap is useful for covering ischial pressure sores and other wounds with lax surrounding tissues. They are commonly used for fingertip injuries when secondary healing is impractical. This flap counts on the deep tissue underlying the flap and the laxity of the surrounding tissues for its blood supply.

Procedure (Fig. 14.5)

1. Determine the site where the surrounding skin laxity is greatest.
2. Draw out the flap by marking the open part of the V at the widest edge of the wound, tapering gradually to a point.
3. Incise the skin edges through the subcutaneous tissue down to, but not into, the underlying fascia and muscle. The flap remains attached to the deep tissues.
4. Advance the flap into the wound defect.
5. Close the defect at the narrow point of the V, creating the vertical or tail component of the Y.
6. Suture the flap under no tension. It is better to have small gaps in the skin closure, which will eventually heal, than a tight closure and have part of the flap necrose.

Gastrocnemius Muscle Flap

A gastrocnemius muscle flap can cover exposed bone or a fracture site involving the proximal one-third of the tibia or the knee. It is best to do this flap within the first couple of weeks after injury before chronic inflammation in the surrounding tissues makes it difficult to mobilize the muscle. The best strategy is to move muscle alone and place an STSG over it.

The gastrocnemius muscle is the most superficial muscle of the posterior compartment of the leg. It originates from the distal femur and joins the underlying soleus muscle forming the Achilles tendon. The blood supply is a single dominant vessel that enters the muscle proximally, near the posterior knee joint. The medial muscle is most often used because it has a better arc of rotation to reach the front of the tibia.

Procedure

1. If available, use a tourniquet for the dissection.
2. Remove all dead bone and other tissue. If in doubt, debride, dress, and return in 3–5 days.
3. Extend the open wound onto the medial calf to visualize the underlying muscle. Try not to

Fig. 14.6 (**a**) An exposed proximal tibia from a shrapnel wound that has been debrided. (**b**) The medial gastrocnemius is harvested through a separate incision. (**c**) The muscle has been tunneled under the fasciocutaneous bridge to cover the exposed bone and will be sutured in place. Definitive closure is obtained with immediate or delayed (5–7 days) STSG

leave intact skin bridges that can compress and necrose the muscle (Fig. 14.6).

4. Separate the gastrocnemius muscle from the overlying skin and underlying soleus muscle. This can often be done with blunt dissection.
5. In the back of the calf, the two heads of the muscle come together at the central raphe, identified by the presence of the sural nerve. Divide the muscle along the raphe, transferring one-half of the muscle, and divide the muscle distally from the Achilles tendon.
6. Bring the muscle around to the defect. Release proximal attachments as needed for length. Usually the origin of the muscle does not require division, but if additional length is required for the muscle to rotate into the defect, divide the origin with care to protect its vascular supply.
7. Once the muscle is freed, release the tourniquet and control bleeding.
8. The muscle should look pink when the tourniquet is removed. If it remains dark or does not bleed, the vascular pedicle has been injured and the muscle is unusable.
9. Suture the muscle loosely to the wound edges. If it cannot completely cover the wound, cover the important structures for which the flap is being made. An STSG can cover the soft tissues now or at a second procedure in 4–5 days.
10. Be sure the muscle is still pink after being sutured in place and is under no tension.
11. Close the skin extension primarily if possible and place a suction or Penrose drain in the defect.
12. Place the leg in a posterior splint, with instructions for bed rest and gentle elevation.

Keep the leg immobilized and elevated for at least 2 weeks after the operation. If the skin graft and all wounds look healthy at that time, the patient can dangle the leg, for a few minutes at a time, gradually increasing over the next few weeks. Gently wrap the leg with a compression bandage for several months to prevent swelling.

Soleus Muscle Flap

The soleus muscle flap is most useful for wounds in the middle of the tibia. This muscle has a segmental blood supply making it less reliable than the gastrocnemius flap. It is also deeper than the gastrocnemius, lying against the tibia, and can be severely damaged in injuries that particularly need coverage, such as open, comminuted, mid-shaft tibial fractures. The dominant vessel enters the soleus muscle in the top half of the muscle with smaller vessels feeding the muscle distally.

There may be cases where the need for tibial coverage exceeds the possibility of either a gastrocnemius or a soleus. When half of each muscle is used, both gastrocnemius and soleus can be used together without jeopardizing the function of ankle plantar flexion.

Procedure

1. If available, use a tourniquet for the dissection.
2. Be sure the wound is adequately debrided and that all the dead tissue and bone are removed.
3. Extend the wound onto the medial calf skin to visualize the underlying muscles. Try not to leave skin bridges, which will compress and diminish the circulation, necrosing the muscle. Identify the gastrocnemius muscle, the most superficial muscle in the calf. The plane of dissection is between the gastrocnemius muscle and the underlying soleus muscle. This can usually be done bluntly or with electrocautery when in the correct plane. Do not separate the gastrocnemius muscle from the skin. Any crossing vessels should be tied off.
4. Bluntly separate the soleus muscle from the muscles of the deep posterior compartment of the leg, taking care to avoid damage to the perforator vessels coming from the posterior tibial artery.
5. Release the tourniquet and control bleeding.
6. Determine whether the vascular supply to the muscle is sufficient to supply the flap by placing a small non-crushing clamp across the vessels that you plan to divide, before the division. If the muscle turns purple when the clamp is placed, the blood vessel you are basing the flap on will ***not*** supply enough circulation to the flap.
7. Divide the vessels not needed for flap viability.
8. Divide the muscle. If the flap is proximally based, divide the muscle from the Achilles tendon; if the flap is distally based, divide the muscle's origin. Bring the muscle to the exposed fracture or wound site.
9. Suture the muscle loosely to the wound edges. If the muscle cannot completely cover the wound, have it cover the exposed bone or tendons. Soft tissues can be covered with an STSG.
10. Place suction or Penrose drains under the muscle flap and from the donor area.
11. Place an STSG over the muscle at this time or in 2–5 days.
12. Place the leg in a splint and keep the leg gently elevated.

Post-op: Same as for gastrocnemius flap.

Excellent descriptions, pictures, and surgical technique for gastrocnemius and soleus flaps are available at GlobalHelp.org and can be downloaded as PDF files.

Fasciocutaneous Flap

Fasciocutaneous flap (Fig. 14.7) provides safe, simple coverage, requiring no special equipment or expertise. Using the 3:1 length to width ratio, skin, subcutaneous tissue, and deep fascia are raised from adjacent tissue and rotated to cover the defect. This random flap relies on the rich vascular network of the deep fascia.

Procedure

1. The flap is outlined allowing sufficient length to rotate it into position.
2. Starting at the end—distal if the flap is proximally based—cut through skin, subcutaneous, and deep fascia, keeping the three layers the same length.
3. Elevate the flap by dissecting in the subfascial plane.
4. Using fine sutures secure the fascia to the subcutaneous to prevent shearing of the layers.
5. The flap can be inset into the wound or if there is any question about its viability, it can be returned and sutured to its bed and inset in 2–3 weeks.
6. Apply STSG to the donor bed and other parts of the wound uncovered by the flap now or at a later date. A drain is advised.

Even with an ex-fix, a plaster back slab will help to prevent motion and equinus contracture.

Distant Flaps

Flaps to cover upper extremity wounds can be taken from the chest or abdomen. They require preop planning to map out a position that allows mobilization of the shoulder, the joints adjacent to the wound, and edema control. Initial postoperative immobilization must be secure enough to prevent the flap from kinking or pulling free when

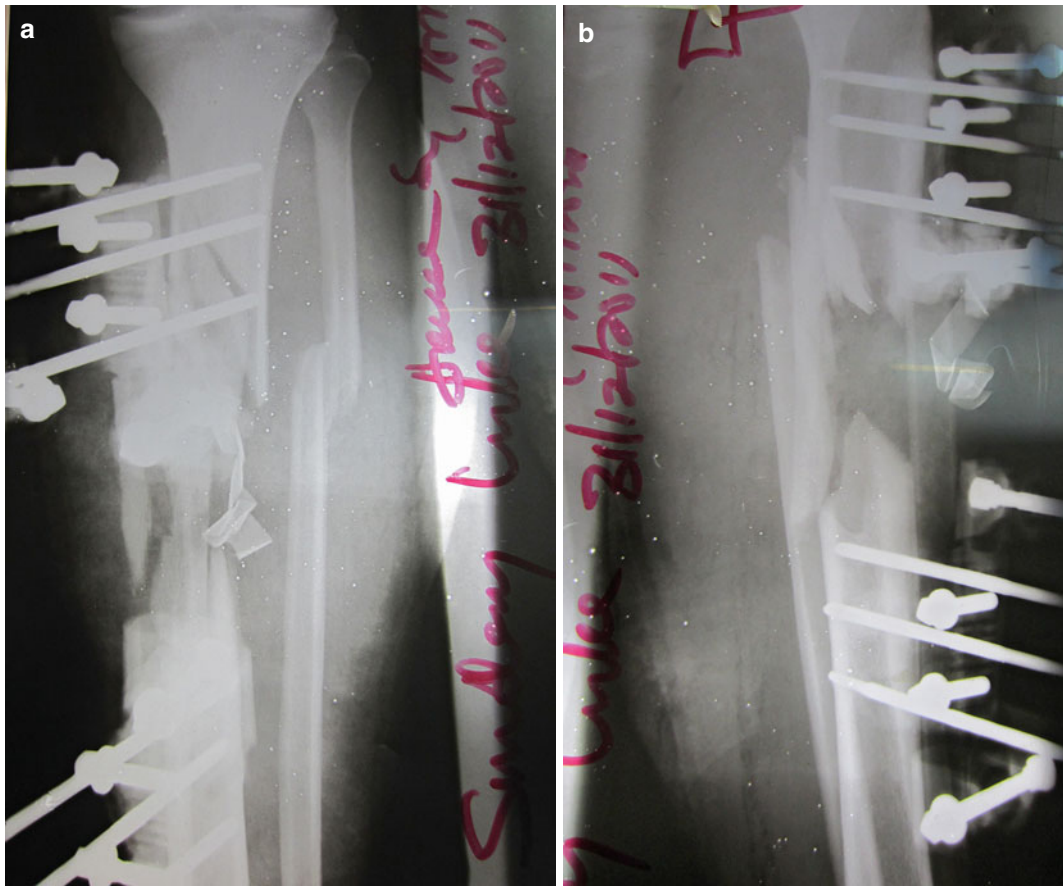

Fig. 14.7 (**a**, **b**) X-rays of a comminuted Gustilo IIIB tib-fib fracture with anterior bone loss. (**c**, **d**) A fasciocutaneous flap has been mobilized from the well-muscled lateral side to cover the bone. Notice exposed lateral (**c**) and medial (**d**) soft tissues uncovered by the flap. (**e**) Five days later medial and lateral STSGs are placed

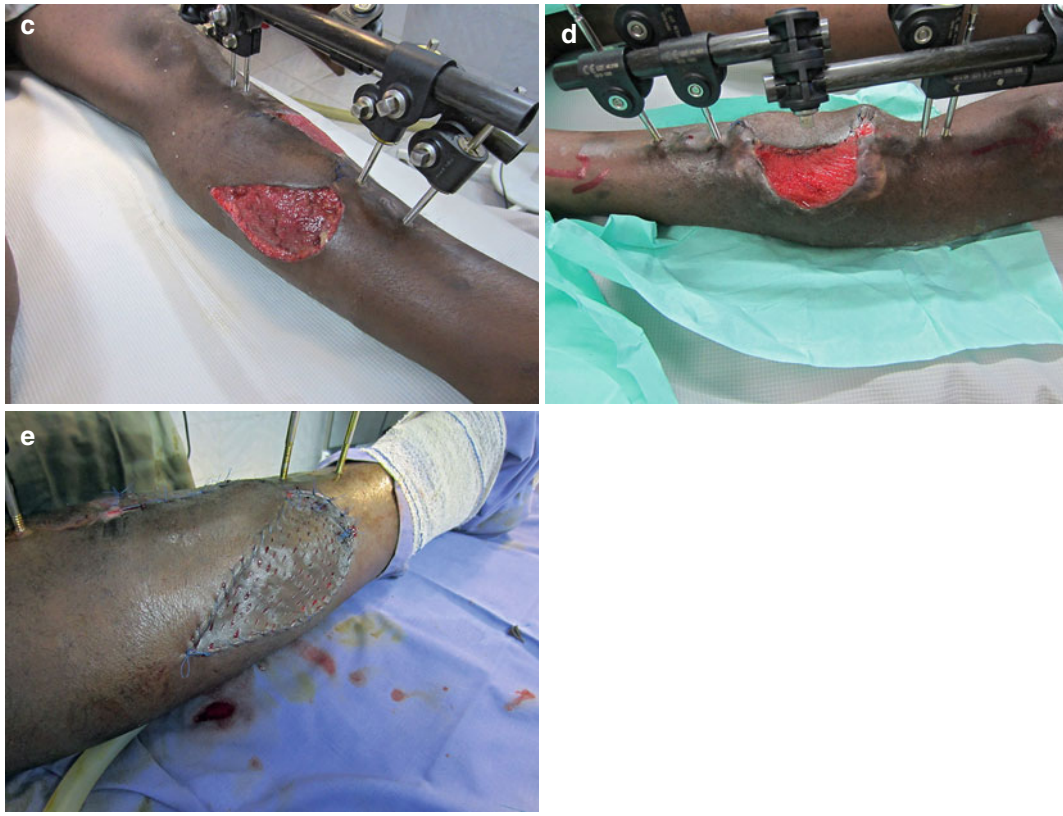

Fig. 14.7 (continued)

the patient awakens from anesthesia. Depending on the wound, these flaps can be done under general, regional, or local anesthesia

Procedure

1. Ask the awake patient to position the injured hand over the chest or abdomen in the most comfortable position. Stay away from breast tissue.
2. Mark this area. The flap should be drawn so that the hand can be comfortably attached and not kink the pedicle. Usually base the pedicle inferiorly, but any orientation can work. Avoid scars from previous injuries.
3. Design the flap so it is slightly larger than the defect.
4. Incise the skin, subcutaneous tissue, and underlying fascia. Do not incise muscle. The fascia contributes to the blood supply to the flap so keep it with the flap whenever possible.
5. Elevate the flap off the deep underlying tissues.
6. Loosely suture the three free sides of the flap in place. Leave small gaps if necessary to prevent a tight closure. Place a drain.
7. If unable to close the donor site, close with an STSG or allow it to heal secondarily.
8. Be sure you can see the flap through your dressings, so its circulation can be evaluated.

Groin Flap

See Fig. 14.8.

Cross-Leg Flap

This is a useful fasciocutaneous flap for complex wounds or fractures involving the distal third

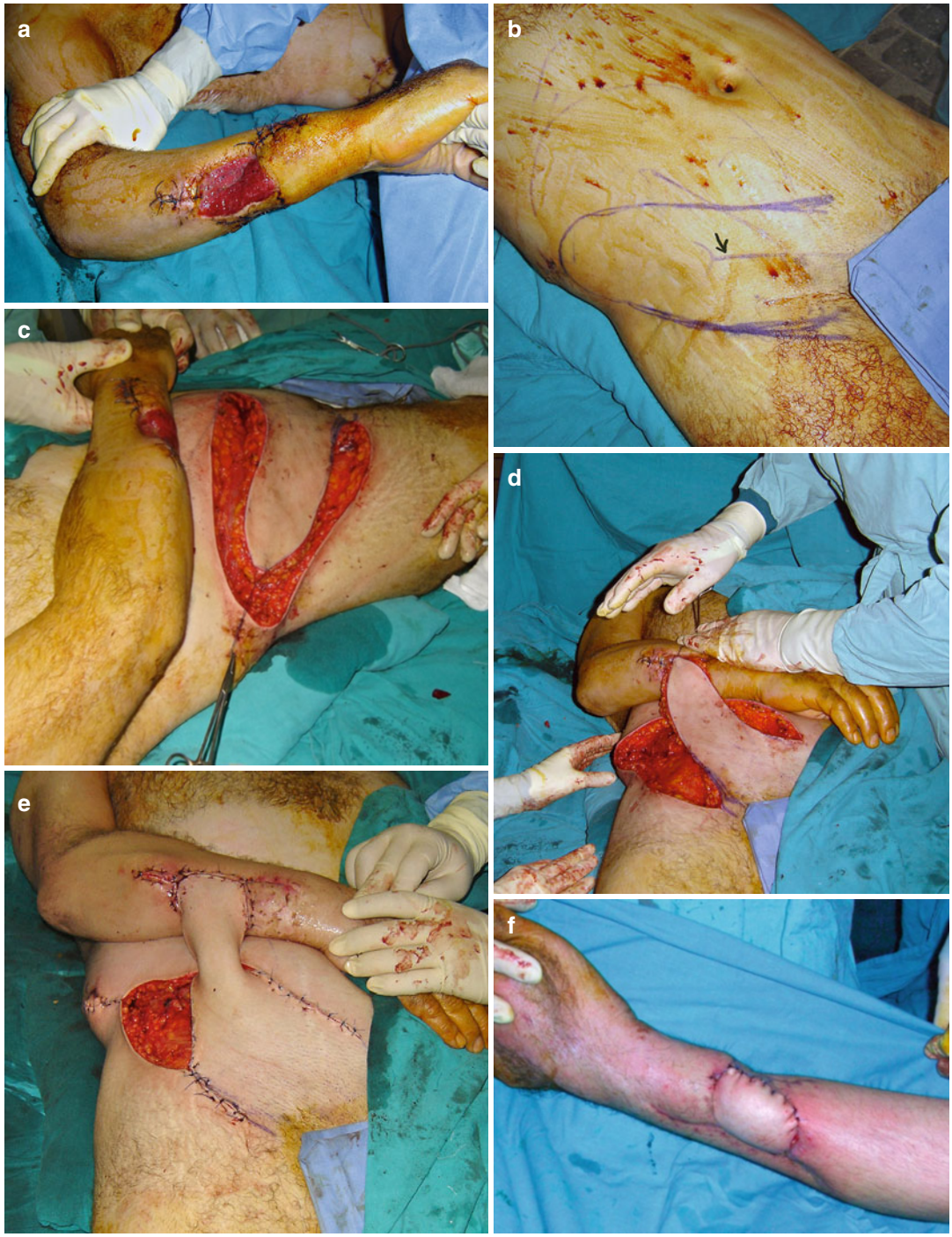

Fig. 14.8 (**a**) A shrapnel wound over the ulnar border of the right forearm, with exposed ulna. (**b**) Drawing of proposed flap, based on the superficial circumflex iliac artery (*arrow*). (**c**) Flap is elevated and (**d**) rotated to cover the defect. (**e**) The flap is tubed and sutured to the recipient site. The donor site is partially closed primarily; the rest will be covered with STSG. (**f**) Appearance after the flap was detached at 3 weeks

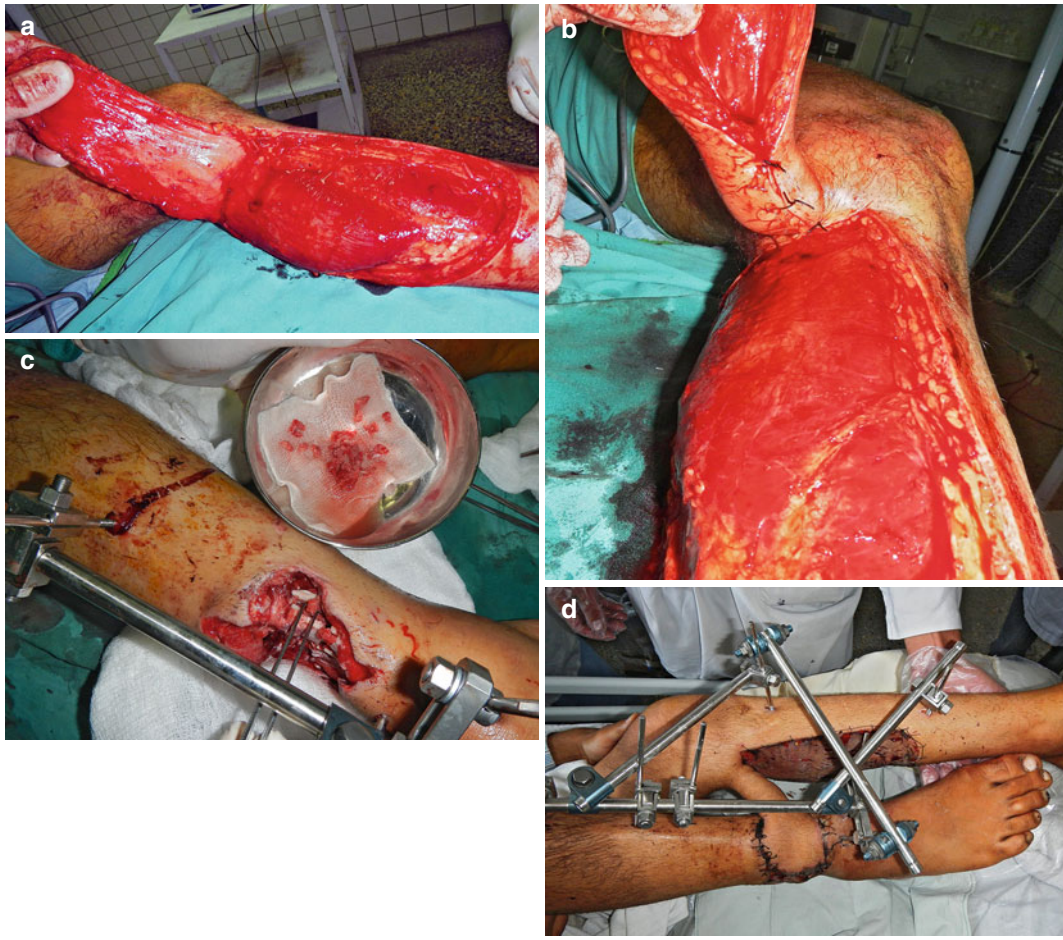

Fig. 14.9 Cross-leg flap. (**a**) A fasciocutaneous flap following the 3:1 length to width rule is raised. (**b**) The base of the flap is tubed to improve maneuverability. (**c**) Cancellous bone chips are placed in the distal tibial defect before the flap is set. (**d**) Appearance 2 weeks after flap inset. Note: an external fixateur or plaster must maintain the legs in position

of the calf, ankle, or foot with exposed tendons or bone. The patient's legs must be immobilized together, in a relatively awkward position for 3–4 weeks, which can result in significant and permanent hip stiffness in adults, making it more useful in patients younger than ~25 years (Fig. 14.9).

Procedure

1. With the patient awake, determine the optimal leg position so that a flap of tissue taken from the non-injured posteromedial calf will lie easily over the defect with the least discomfort.
2. Draw the flap, slightly larger than the defect, with the pedicle based superiorly.
3. Incise the skin, subcutaneous tissue, and fascia as described above for fasciocutaneous flap.
4. Loosely suture the three free sides of the flap in place and place a drain.
5. Cover the donor site with STSG.
6. Immobilize the legs together. In children use a plaster hip spica cast with a bar connecting the legs. Window the plaster over the flap so it can be observed and cleaned. In adults, the plaster can often be loosened or removed after a few

days, but children will need to remain immobilized. An external fixateur will hold the position and also allow good access to the wounds.

General post-op care for all flaps involves cleaning the suture lines with saline or gentle soap and water. Apply antibiotic ointment if available.

Postoperative Troubleshooting

If any of the above mentioned flaps become swollen or bluish within a few hours of the operation, the circulation has been compromised—usually a venous, outflow problem.

1. Check positioning, especially if a distant flap, make sure the pedicle is not kinked.
2. Loosen the dressings.
3. Remove a few sutures.
4. Be sure no hematoma lies under the flap.
5. Be sure the patient is warm and has adequate pain control.

Flap division for distant flaps can usually be done ~4 weeks after the initial flap creation. If occlusion of the pedicle with fingers or an atraumatic clamp for 30 s creates pallor or loss of capillary refill, the flap should not be completely divided at that time.

Scar Modalities

Complete wound healing and scar maturation takes many months. Prevention of scar contracture is critical for optimal outcomes, especially when dealing with hand injuries. Simple scar massage is highly effective and can be done by the patient or family or a traditional healer. Two to three times each day, gentle massage to the scar will gradually soften the tissues and improve range of motion. Moisturizing lotions are useful and rural communities have local plant products that can be used. Massage needs to continue for months after the injury to limit tightness and contracture that can lead to decreased mobility and disability.

Tight, immobile scars unfortunately are common in patients who sustain deep burns to the hand, antecubital fossa, axilla, and neck. The best treatment is prevention by splinting, range of motion exercises, early skin grafting, and scar modalities. However, when contractures are present, morbidity can be extreme. Z-plasty is a technique whereby the scar tissue is rearranged to lengthen the scar and improve mobility. Due to the geometry of creating the Z-plasty flaps, the gain in length is coupled with a loss of width, which can be problematic. In general, a more reliable way to treat scar contractures is to cut into or resect the tight scar to allow full range of motion at the joint and cover the resultant defect with a full-thickness skin graft. Be sure to use splints to immobilize the area and promote graft "take," as well as prevent contracture recurrence. For fingers K-wires will keep the fingers in proper position; for children casting may also be necessary.

References

1. Field FK, Kerstein MD. Overview of wound healing in a moist environment. Am J Surg [Internet]. 1994 [cited 2012 Aug 13];167(1A):2S–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8109679.
2. Bui TD, et al. Negative pressure wound therapy with off-the-shelf components. Am J Surg. 2006;192:235–7.
3. Richards B. Negative pressure wound therapy. In: Richards B. An orthopod's workbench [Internet]. 2010 [cited 2012 Aug 2]. Available from: http://orthopodsworkbench.blogspot.com/2010/05/negative-pressure-wound-therapy.html.

Suggested Reading from global-help.org as Free Downloads

Kelleher J. Abdominal pedicle flaps to the hand and forearm. 2004. http://global-help.org/products/abdominal_pedicle_flaps_to_the_hand__forearm/.

McCraw JB, Arnold PG, McCraw and Arnold's atlas of muscle and musclocutaneous flaps. 1986 and 2007. http://global-help.org/products/mccraw__arnolds_atlas_of_muscle_and_musculocutaneous_flaps/.

Semer N. Basics of wound care. 2003. http://global-help.org/products/basics_of_wounds_care/.

Semer N. Practical plastic surgery for non-surgeons. 2011. http://global-help.org/products/practical_plastic_surgery_for_nonsurgeons/.